10/568293
IAP9 Rec'd PCT/PTO 15 FEB 2006
PCT/GB2004/003534

Structural Support Beam

This invention relates to a structural support beam manufactured from a composite of materials, and in particular, but not exclusively, to a composite of timber in various forms with an infill of material that provides both added structural support and thermal/sound insulation, for use in the building and construction industry.

Support beams of the form of Laminate Veneer Lumber (LVL), Parallam products, Glulam products, I-joists and Box Beams, are known. These different support beams offer different structural properties and are used in different designs for different applications. For example, Parallam products have a high stiffness and strength compared to the other above-mentioned beams, but are heavier, more abrasive to saw and drill, require connection be made to adjacent beams with metal plates and bolts or dowels rather than nails, and are relatively costly; LVL products provide strength and consistent

performance, are easy to work with, can be cut and nailed on site, resist shrinkage, warping, splitting and checking, but are relatively costly.

Box beams are also known as shown in Fig.1. These typically consist of solid timber or LVL flanges with plywood or Oriented Strand Board (OSB) webs. The webs are glued and/or mechanically connected to the flanges on each side to form a box shape.

Box beams are moderately lightweight, can be handled easily, allow a higher load capacity than comparable sized timber, resist shrinkage, warping and checking and are more efficient than solid timber for large spans and loads.

However, such box beams are susceptible to shear buckling and therefore require web stiffeners to be positioned at points of increased load to counter localised web buckling. Furthermore, holes in the web can only be located where shear loads are low.

According to a first aspect of the present invention there is provided a structural support beam for use in building and construction comprising a support frame defining at least one volume, said support frame being of a first material and said at least one volume being in-filled with a second material.

Preferably, the support frame comprises two spaced apart flanges connected by at least two outer support webs.

Preferably, each outer support web connects lateral portions of the flanges.

Optionally, one or more additional outer support web(s) is/are positioned over one or both of the existing outer support webs.

Preferably, one or more inner support webs connect the flanges in an intermediate position between the outer support webs.

Optionally, one or more formations are provided in each flange to accommodate the outer support webs.

Optionally, one or more formations are provided in each flange to accommodate the inner support web or webs.

Preferably, the formations are one or more of grooves, recesses and cut-out portions.

Preferably, the flanges are rectangular in shape.

Preferably, each flange is fully interposed between the outer support webs.

Optionally, each flange is provided with a reduced width portion to define a T-shaped flange.

Preferably, each reduced width portion is fully interposed between the outer support webs.

Preferably, the lateral edges of the other portions are adapted to be flush with the outer surfaces of the outer support webs.

Alternatively, the lateral edges of the other portions are adapted to extend beyond the outer surfaces of the outer support webs.

Optionally, a further end-flange is connected to the outer end of each existing flange.

Preferably, the lateral edges of each end-flange are adapted to be flush with the outer surfaces of the outer support webs.

Alternatively, the lateral edges of each end-flange are adapted to extend beyond the outer surfaces of the outer support webs.

Optionally, metal end plates are connected to the outer end of each flange.

Optionally or additionally, the metal end plates are connected to the outer end of each end-flange.

Preferably, the second material is less dense than the first material.

Preferably, the second material is a plastics foam material.

Preferably, the second material is adapted to give the support beam improved thermal and/or sound insulating properties.

Alternatively or additionally, the second material is adapted to give the support beam improved structural properties.

Preferably, the support frame is made from timber materials.

According to a second aspect of the present invention there is provided a structural support beam for use in building and construction comprising a timber based support frame formed from two spaced apart rectangular flanges connected by at least two outer support webs wherein the timber based support frame defines at least one volume in-filled with a plastics foam material; and wherein the plastics foam material is bonded to the flanges and webs.

Preferably, the outer support webs extend over the full depth of the flanges.

Preferably, the flanges are formed from solid or laminated timber material and the webs are formed from timber sheet material.

According to a third aspect of the present invention there is provided a method of manufacturing the structural support beam of the first aspect, said method comprising the steps of:

(i) connecting two spaced apart flanges by means of at least two outer support webs to form a support frame defining at least one volume; and

(ii) filling said at least one volume with an in-fill of material.

Preferably, the method comprises the additional step of bonding said in-fill of material to the support frame.

Preferably, the method comprises the further additional step of gluing and/or mechanically fixing the outer support webs to the flanges.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Fig. 1 is a cross-sectional view of a known box beam;

Fig. 2 is a cross-sectional view of a support beam made in accordance with the present invention;

Figs. 3a-b are cross-sectional views of the apparatus of Fig. 2 with additional end-flanges to form an I-beam showing fasteners visible from the outside, and not visible from the outside, respectively;

Figs. 4a-b are cross-sectional views of the

apparatus of Fig. 2 with additional end-flanges to form a box beam showing fasteners visible from the outside, and not visible from the outside, respectively;

Fig. 5a is a cross-sectional view of the apparatus of Fig. 2 with an additional inner support web;

Fig. 5b is a cross-sectional view of the apparatus of Fig. 2 with two additional inner support webs;

Figs. 5c-d are cross-sectional views showing alternative profiles of the connections of the inner support webs to the flanges.

Figs. 6a-b are cross-sectional views of the apparatus of Fig. 2 with an additional lateral support web connected to one and both of the outer face(s) respectively of the apparatus of Fig. 2;

Fig. 7 is a cross-sectional view of an alternative support beam having T-flanges to form an I-beam;

Fig. 8 is a cross-sectional view of an alternative support beam having T-flanges to form a box beam;

Fig. 9 is a cross-sectional view of an

alternative beam support having grooved flanges to form an I-beam;

Fig. 10 is a cross-sectional view of a further alternative beam support having recessed flanges to form an I-beam;

Fig. 11 is a cross-sectional view of an alternative support beam having rectangular flanges to form an I-beam;

Fig. 12 is a cross-sectional view of the apparatus of Fig. 11 having additional supports at the junctions between the flanges and the lateral support webs;

Fig. 13 shows cross-sectional views of adapted embodiments of the present invention: (a) is the apparatus of Fig. 2 with metal end plates added to the flanges; (b) is the apparatus of Fig. 3a having metal end plates added to the flanges; (c) is an alternative arrangement to (b); (d) is the apparatus of Fig. 8 with metal end plates added to the flanges; (e) is the apparatus of Fig. 9 with metal end plates added to the flanges; (f) is the apparatus of Fig. 5 adapted with both additional end-flanges and metal end plates;

Fig. 14 is a comparison of the load-deformation characteristics of a sample of embodiments made in accordance with the present invention under

direct compression loads; and

Fig. 15 is a qualitative table comparing known support beams to those of the present invention.

Referring to the drawings, Fig. 1 shows a known box beam 10 consisting of two spaced apart horizontal flanges 16, 18 connected by the respective ends of two opposing vertical webs 12, 14 to form a box shape. Typically, the webs 12, 14 are glued to the flanges 16, 18 and/or mechanically connected during manufacture. Throughout the specification, the term "box beam" is used to refer to a beam having an overall rectangular shape.

In a first embodiment of the present invention, as shown in Fig. 2, there is a structural support beam in the form of a box beam 100. The term "structural support beam" used throughout the specification is intended to refer to support beams possessing structural characteristics suitable for use as load-bearing flexural members. The structural support beam comprises two flanges 116, 118 connected by the respective ends of two opposing laterally arranged vertical support webs 112, 114 to form a support frame in the shape of a box.

The outer support webs 112, 114 are glued and or mechanically connected to the flanges 116, 118. Typically, the flanges are of solid sawn timber, Glulam or LVL, and the webs are of a timber sheet

product such as plywood or Oriented Strand Board (OSB).

The box beam 100 further includes an infill of support/insulating material 110 within a volume defined by the outer support webs 112, 114 and flanges 116, 118. The material 110 is less dense than the timber material from which the flanges and outer support webs are formed.

The material 110 is a plastics foam, for example, expanded polystyrene (EPS), extruded polystyrene, urethane, or other similar insulation cores that are bonded to the outer support webs 112, 114 and flanges 116, 118 to form a close contact. The material 110 may be of any type to improve both the insulation (thermal and/or sound) and/or structural properties of the box beam 100. The material 110 may be bonded to the interior surfaces of the outer support webs 112, 114 and the flanges 116, 118.

In a second embodiment of the present invention, as shown in Figs. 3a-b, there is a structural support beam in the form of an I-beam 200 comprising substantially the same box beam 100 as described above with the addition of further end-flanges 220, 222 (which will hereinafter be referred to as I-flanges) connected to flanges 116, 118 (which will hereinafter be referred to as box-flanges) to form an I-shaped support frame. The I-flanges 220, 222 are glued and/or mechanically connected to the box-flanges 116, 118. Mechanical connectors can either

be located through the I-flanges to the box-flanges as shown in Fig. 3a or can be located from the box-flanges to the I-flanges as shown in Fig. 3b so as not to be visible from the outer surface of the I-beam 200.

In a third embodiment of the present invention, as shown in Figs. 4a-b, there is a structural support beam in the form of a box beam 300 comprising substantially the same box beam 100 as described above with the addition of further end-flanges 320, 322 (hereinafter referred to as flush-flanges) the lateral edges of which are adapted to be flush with the outer surfaces of the opposing laterally arranged outer support webs to form a box beam. The flush-flanges 320, 322 are glued and/or mechanically connected to the box-flanges 116, 118. Mechanical connectors can either be located through the flush-flanges to the box-flanges as shown in Fig. 4a or can be located from the box-flanges to the flush-flanges as shown in Fig. 4b so as not to be visible from the outer surface of the box beam 300.

In a fourth embodiment of the present invention, as shown in Fig. 5a, there is a structural support beam in the form of a boxed I-beam 400 comprising substantially the same box beam 100 as described above with the addition of a further inner support web 424 connecting box flanges 416, 418. The inner support web 424 lies parallel with the opposing outer support webs 112, 114 in an intermediate position between the outer support webs. The box

flanges 416, 418 are each provided with a groove 426, 428, each groove being adapted to receive a respective end of the inner support web 424 and retain it in position within the respective box flanges 416, 418. The web 424 may be rigidly fitted within the grooves 426, 428 and/or glued and/or mechanically connected. Fig. 5b shows a structural support beam as described in the previous paragraph having two inner support webs 424 to form a boxed double I-beam. The in-fill material may be bonded to the interior surfaces of the outer support webs 112, 114 and the flanges 116, 118 and to both surfaces of the inner support web(s).

Figs. 5c-d show alternative profiles of the connections between the inner support webs 424 and the grooves 426, 428. Fig. 5c shows an inner support web 424 having a rectangular end profile and Fig. 5d shows an inner support web having a tapered end profile.

In a fifth embodiment of the present invention, as shown in Figs. 6a-b, there is a structural support beam in the form of a box beam 500 comprising substantially the same box beam 100 as described above with additional laterally arranged outer support webs 513, 515 being connected to the outer surface of one or both outer support webs 112, 114. The additional laterally arranged outer support webs 513, 515 could be glued and/or mechanically connected to their respective outer support webs 112, 114.

In a sixth embodiment of the present invention, as shown in Fig. 7, there is a structural support beam in the form of an I-beam 600 comprising two T-shaped flanges 616, 618, (T-flange 616 being inverted), connected by the respective ends of two opposing outer support webs 612, 614 to form an I-shaped support frame. Each T-shaped flange comprises a reduced diameter stem portion. The stem portions are formed by cutting away two rectangular corner portions from a regular rectangular flange. The outer support webs 612, 614 can be glued and/or mechanically connected to the lateral sides of the stem portions of the T-shaped flanges 616, 618. The outer support webs 612, 614 and flanges 616, 618 define a volume having an infill of support/insulating material 610 substantially the same as material 110 as hereinbefore described.

In a seventh embodiment of the present invention, as shown in Fig. 8, there is a structural support beam in the form of a box beam 700 comprising two T-shaped flanges 716, 718, (T-flange 716 being inverted), the lateral edges of which are adapted to be flush with the outer surfaces of the opposing outer support webs 712, 714 to form a box beam. The outer support webs 712, 714 can be glued and/or mechanically connected to the stem portions of the T-shaped flanges 716, 718. The webs 712, 714 and flanges 716, 718 define a volume having an infill of support/insulating material 710 substantially the same as material 110 as hereinbefore described.

In an eighth embodiment of the present invention, as shown in Fig. 9, there is a structural support beam in the form of an I-beam 800 comprising two double grooved flanges 816, 818 connected by the respective ends of two opposing outer support webs 812, 814 to form an I-shaped support frame. The respective outer support webs 812, 814 are each located within grooves 824a-826b provided on the double grooved flanges 816, 818. The outer support 812, 814 may be rigidly fitted within grooves 824a-826b and/or glued and/or mechanically fastened to the double grooved flanges 816, 818. The outer support webs 812, 814 and double grooved flanges 816, 818 define a volume having an infill of support/insulating material 810 substantially the same as material 110 as hereinbefore described.

In a ninth embodiment of the present invention, as shown in Fig. 10, the I-beam 800 has been adapted to form a new structural support beam or I-beam 900. Single recesses 925, 927 replace the double grooves 824a-826b of the flanges 816, 818. The outer support webs 812, 814 can be accommodated within part of each single recess 925, 927 and an infill of support/insulating material 910 substantially the same as material 110 as hereinbefore described is provided in the volume defined by the outer support webs and the single recessed flanges.

In a tenth embodiment of the present invention, as shown in Fig. 11, there is a structural support beam

in the form of an I-beam 1000 comprising two rectangular I-flanges 1016, 1018 connected between respective ends of two outer support webs 1012, 1014 to form an I-shaped support frame. The outer support webs 1012, 1014 and flanges 1016, 1018 define a volume having an infill of support/insulating material 1010 substantially the same as material 110 as hereinbefore described.

In an eleventh embodiment of the present invention, as shown in Fig. 12, the I-beam 1000 has been adapted to form a new structural support beam or I-beam 1100, wherein, support members 1101-1104 are glued and/or mechanically connected at the junction region between the ends of outer support webs 1012, 1014 and the I-flanges 1016, 1018.

It will be appreciated by those skilled in the art that mechanical fixing of the outer support webs and flanges can be carried out by any suitable means, for example by nails, staples, screws, bolts etc.

It will further be appreciated that each of the foregoing embodiments can be adapted or modified to include features of any of the other embodiments. For example, the additional inner support web(s) of Figs. 5a-b may be easily incorporated into any of the other embodiments. Equally, any one of the embodiments can easily be modified or adapted to give improved structural properties. For example, Fig. 13 shows how some of the embodiments may be fitted with metal plates to improve their structural

characteristics.

Moreover, it will be appreciated by those skilled in the art that the integrity of the flanges affects the structural qualities of a support beam. In particular, the connection of the outer support webs to the flanges is an important area in terms of structural integrity. For example, the absence of grooves, recesses and cut out portions in otherwise rectangular shaped flanges (e.g. see Figs. 2-4, 6 and 11-13c) offers several advantages. By rectangular, it is meant that the flanges are of a regular four-sided rectangular or square shape without any formations such as grooves recesses or cut-out portions to accommodate the outer support webs. Rectangular flanges offer several advantages as follows: (i) Ease of Construction - the simplicity of the design avoids the need for expensive grooving and close tolerances; (ii) Strength and Stiffness - the presence of grooves or recesses within the flanges creates areas of weakness and hence reduces the bending and longitudinal shear strength capacity of the structural beam. For a set beam depth (often governing the design and detailing criteria), a box shaped design such as that shown in Fig. 2 will provide a stronger beam in bending (due to the fully intact flanges) and in shear (due to outer support webs extending to the full depth of the flanges) and therefore an overall stiffer solution; (iii) Greater Dimensional Stability - the absence of grooving increases dimensional stability and reduces the

possibilities for differential shrinkage in flanges which can lead to cracking; and (iv) Cost - grooving is an expensive part of the manufacturing process both in terms of preparation and assembly as specialised jigs and clamps are required. The exclusion of grooves and recesses thus leads to a lower cost solution with the added benefit of performance gains.

The support beams of the present invention incorporate both structural and insulation qualities into a single member during manufacture thus achieving higher quality, more accurate thermal and/or sound efficiency and an increased level of structural support.

The structural beams of the present invention can also be produced in varying sizes and thickness depending on the particular application and insulation/structural requirements.

The material 110-1010 not only provides thermal and/or sound insulation, but also provides increased structural properties as demonstrated by Fig. 14, the results of which are described below.

Samples of the aforementioned embodiments described above have been tested (under static compression) to establish their structural properties. The apparatus tested was:

(A) and (B) which are the support beams of Figs. 2

and 1, i.e. with and without the infill of material 110 respectively;

(C) and **(D)** which are the support beam of Fig. 9 and a corresponding support beam without an infill of material respectively;

(E) and **(F)** which are the support beams of Fig. 5a and a corresponding support beam without an infill of material respectively; and

(G) and **(H)** which are the support beams of Fig. 8 and a corresponding support beam without an infill of material respectively.

For all support beams, corresponding flanges were cut from Whitewood grade C16 timber. The corresponding outer support webs were cut from 11mm thick OSB grade 3 panels and the infill material was 95mm thick expanded polystyrene (EPS). All contact surfaces were glued together, and where appropriate, were screwed using 2x8 woodscrews.

In comparing the support beams with the infill of material (**A, C, E** and **G**) and without the infill of material (**B, D, F** and **H**), there is generally an increase in the ultimate load capacity and ductility of the support beams having the infill of material.

Advantageously, the infill material adds very little overall weight to each support beam, yet it provides a significantly increased ultimate load capacity.

Furthermore, the requirement for I-beams and box beams to have web stiffeners at areas prone to localised buckling may be dispensed with due to the increased ultimate load capacity of the support beams having the infill of material.

Moreover, the results shown in Fig. 14 show that the support beams having the infill of material (**A**, **C**, **E**, **G**) can carry the same load for an increased deflection/displacement, i.e. they have enhanced ductility qualities.

In particular, supports beams (**C**) and (**D**) are worthy of further comment. The infill of material in support beam (**C**) exhibits an interesting quality in that it appears to affect the failure mode of the support beam. Although support beam (**D**) appears to fail suddenly at a displacement of approximately 4mm, support beam (**C**) appears to initially fail at a displacement of approximately 5mm yet can still hold the load applied for a further 4mm of displacement. This shows the level of enhanced ductility provided by the infill material of support beam (**C**).

Overall the results clearly demonstrate that the addition of an inner support web connected between the flanges within the infill of material exhibit a far higher ultimate load capacity. From this result, it can be extrapolated that the addition of one or more inner support web(s) may increase the ultimate load capacity of any support beam design.

Having conducted the above tests, Fig. 15 shows a qualitative comparison of the structural support beams of the present invention with known designs.

The structural support beams of the present invention may be used in any building and construction projects. The support beams may be in the form of I-beams, double I-beams, box-beams, boxed I-beams or boxed double I-beams.

Modifications and improvements may be made to the above without departing from the scope of the present invention. For example, the infill material 110-1010 may be pre-fabricated, in which case, the respective outer support webs and flanges of a support frame may be bonded directly to the pre-fabricated material 110-1010. The infill material may be formed from either open cell, closed cell or a mixture of open and closed cell foam materials. Alternatively, the infill material may be formed from a wood-based material or any other suitable material providing the desired structural and/or thermal/sound insulating properties.

Alternatively, the material 10-1010 may be injected into a volume defined by a support frame of outer support webs and flanges, wherein the material expands to fill the volume. The respective contact surface of the support frame may have bonding means to assist on securing and ensuring a close contact with the infill of material 10-1010 to the support frame.